REMARKS

Claims 18-59 are in the application.

DRAWINGS

The drawings are rejected because Figs. 6A-6B were not labeled "Prior Art". Applicant has provided Replacement Sheet with the Figures labeled as "Prior Art".

WRITTEN DESCRIPTION

Claims 18-59 are rejected under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the written description requirement.

Claims 18, 21 43 and 46 each utilize a "thermodynamic analysis" and a "consistency analysis" [or similar], which are allegedly unclear from the present specification.

The examiner alleges that the specification fails to teach a specific "type" of analysis as claimed, and thus the correspondence between the claim language and the specification is unclear. In fact, this is not material issue, since these terms are self-defined within the claims. For example, claim 18 provides:

> An apparatus, comprising:
>
> a memory, storing parameters of a model of a refrigeration system derived from measurements of actual operational parameters of the refrigeration system;
>
> at least one input for receiving physical parameters sufficient for performing a thermodynamic analysis of the refrigeration system;
>
> a processor for performing a thermodynamic analysis of the refrigeration system in an operating state and determining consistency of the thermodynamic analysis with the stored parameters in the memory; and
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> an output for presenting an estimate of deviance from an optimal state of the refrigeration system based on said thermodynamic analysis and said determined consistency.

Claim 18 thus provides an apparatus which performs a "thermodynamic analysis" based on received physical parameters. As is known, in a closed system, the thermodynamic analysis analyzes temperatures, pressures, flows, enthalpy, entropy, power, etc., and is the subject of basic chemistry and physics courses, well known to those of ordinary skill in the art and indeed, to the examiner (http://www.uspto.gov/go/ac/ahrpa/ohr/jobs/qualifications.htm). To deny the laws of physics is futility. The patent system does not demand that each applicant replicate the

entire body of knowledge that precedes its invention verbatim in order to use or enhance that body; the use of words common in the art and well known, for their common and accepted meaning, are sufficient. See http://en.wikipedia.org/wiki/Thermodynamics (repeated in part, with minor edits, below):

> In physics, **thermodynamics** (from the Greek θερμη, *therme,* meaning "heat"[1] and δυναμις, *dynamis,* meaning "power") is the study of the conversion of heat energy into different forms of energy (in particular, mechanical, chemical, and electrical energy); different energy conversions into heat energy; and its relation to macroscopic variables such as temperature, pressure, and volume. Its underpinnings, based upon statistical predictions of the collective motion of particles from their microscopic behavior, is the field of statistical thermodynamics, a branch of statistical mechanics.[2][3][4] Roughly, heat means "energy in transit" and dynamics relates to "movement"; thus, in essence thermodynamics studies the movement of energy and how energy instills movement. Historically, thermodynamics developed out of need to increase the efficiency of early steam engines.[5]
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> The starting point for most thermodynamic considerations are the laws of thermodynamics, which postulate that energy can be exchanged between physical systems as heat or work.[6] They also postulate the existence of a quantity named entropy, which can be defined for any system.[7] In thermodynamics, interactions between large ensembles of objects are studied and categorized. Central to this are the concepts of *system* and *surroundings*. A system is composed of particles, whose average motions define its properties, which in turn are related to one another through equations of state. Properties can be combined to express internal energy and thermodynamic potentials, which are useful for determining conditions for equilibrium and spontaneous processes.
>
> With these tools, thermodynamics describes how systems respond to changes in their surroundings. This can be applied to a wide variety of topics in science and engineering, such as engines, phase transitions, chemical reactions, transport phenomena, and even black holes. The results of thermodynamics are essential for other fields of physics and for chemistry, chemical engineering, aerospace engineering, mechanical engineering, cell biology, biomedical engineering, materials science, and economics to name a few.[8][9]
>
> * * *
>
> ## The laws of thermodynamics
>
> In thermodynamics, there are four laws that do not depend on the details of the systems under study or how they interact. Hence these laws are very generally valid, can be applied to systems about which one knows nothing other than the balance of energy and matter transfer. Examples of such systems include Einstein's prediction of spontaneous emission around the turn of the 20th century, and ongoing research into the thermodynamics of black holes.

These four laws are:

- Zeroth law of thermodynamics, about thermal equilibrium:

  If two thermodynamic systems are separately in thermal equilibrium with a third, they are also in thermal equilibrium with each other.
  If we grant that all systems are (trivially) in thermal equilibrium with themselves, the Zeroth law implies that thermal equilibrium is an equivalence relation on the set of thermodynamic systems. This law is tacitly assumed in every measurement of temperature. Thus, if we want to know if two bodies are at the same temperature, it is not necessary to bring them into contact and to watch whether their observable properties change with time.[13]

- First law of thermodynamics, about the conservation of energy:

  The change in the internal energy of a closed thermodynamic system is equal to the sum of the amount of heat energy supplied to the system and the work done on the system.

- Second law of thermodynamics, about entropy:

  The total entropy of any isolated thermodynamic system tends to increase over time, approaching a maximum value.

- Third law of thermodynamics, about the absolute zero of temperature:

  As a system asymptotically approaches absolute zero of temperature all processes virtually cease and the entropy of the system asymptotically approaches a minimum value; also stated as: "the entropy of all systems and of all states of a system is zero at absolute zero" or equivalently "it is impossible to reach the absolute zero of temperature by any finite number of processes".

The following has sometimes been called the "Fourth Law of Thermodynamics".

- Onsager reciprocal relations:

  In connected thermodynamic systems which are in equilibrium neither for pressure nor temperature, heat flow between is caused by forces proportional with unit of pressure difference, and equal to the proportional density flow caused per unit of temperature difference.
  See also: Bose–Einstein condensate and negative temperature.

Thermodynamic potentials

As can be derived from the energy balance equation (or Burks' equation) on a thermodynamic system there exist energetic quantities called thermodynamic potentials, being the quantitative measure of the stored energy in the system. The five most well known potentials are:

Internal energy	U
Helmholtz free energy	$A = U - TS$
Enthalpy	$H = U + PV$
Gibbs free energy	$G = U + PV - TS$
Grand potential	$\Phi_G = U - TS - \mu N$

Other thermodynamic potentials can be obtained through Legendre transformation. Potentials are used to measure energy changes in systems as they evolve from an initial state to a final state. The potential used depends on the constraints of the system, such as constant temperature or pressure. Internal energy is the internal energy of the system, enthalpy is the internal energy of the system plus the energy related to pressure-volume work, and Helmholtz and Gibbs energy are the energies available in a system to do useful work when the temperature and volume or the pressure and temperature are fixed, respectively.

A thermodynamic analysis is thus a quantitative analysis of a system in accordance with the laws of thermodynamics. All proper thermodynamic analyses comprise essentially equivalent considerations, and there is no need to detail the conduct of such an analysis to a person or ordinary skill, since the laws of thermodynamics are well known and understood, and not believed to be materially disputed. In this case, the system is a refrigeration system. It is believed that the phrase "thermodynamic analysis" is well known to those of ordinary skill in the art, and therefore its use is not overly ambiguous. Wikipedia provides a relevant entry, a copy of which was previously provided. Note the correspondence of Fig. 2 of the Wikipedia entry with Fig. 6B of the present application.

A consistency analysis is an analysis of a model of a refrigeration system, that is, one which seeks to reconstruct the system from the understood characteristics components and stated parameters and perturbations, as compared to the performance of the actual system being modeled. The consistency, or lack thereof, provides an indication that the actual system differs

or deviates from the model. An inconsistency may reveal that any actual measurements agree with parameters theoretically derived from the model, and the system configuration has not changed, or that the thermodynamic parameters of the system themselves have changed. This, in turn, leads to the possibility of determining that a repair or remediation is appropriate in order to restore the system to a known-good state. Thus, the consistency analysis provides a basis for determining when a repair or maintenance procedure is useful, and indeed since the analysis is potentially quantitative and based on the laws of thermodynamics, the consistency analysis may also predict a potential quantitative benefit from the proposed service or maintenance, permitting a cost-benefit analysis.

Indeed, the specification is believed to address these particular issues. The specification references a number of sources which help define, to the extent necessary, the meaning of the claim phrases. See, e.g., Thome, J.R., "Comprehensive Thermodynamic Approach to Modelling Refrigerant-Lubricating Oil Mixtures", Intl. J. HVAC&R Research (ASHRAE) 1995, 110-126; and Poz, M. Y., "Heat Exchanger Analysis for Nonazeotropic Refrigerant Mixtures", ASHRAE Trans. 1994, 100(1)727-735 (Paper No. 95-5-1). Pages 35-36 of the specification describe the basis for the thermodynamic analysis, while the thermodynamic analysis is described generally throughout the background and summary of the invention.

A consistency analysis is clearly discussed and defined in the specification; see page 15, line 24-page 16, line 5:

> According to another embodiment of the invention, a set of state measurements are taken of the refrigeration system, which are then **analyzed for self-consistency** and to extract fundamental parameters, such as efficiency. **Self-consistency, for example, assesses presumptions inherent in the system model, and therefore may indicate deviation of the actual system operation from the model operation**. *As the actual system deviates from the model, so too will the actual measurements of system parameters deviate from their thermodynamic theoretical counterparts*. For example, as heat exchanger performance declines, due for example to scale accumulation on the tube bundle, or as compressor superheat temperature increases, for example due to non-condensable gases, these factors will be apparent in an adequate set of measurements of a state of the system. Such measurements may be used to estimate the capacity of the refrigeration system, as well as factors which lead to inefficiency of the system. These, in turn, can be used to estimate performance improvements which can be made to the system by returning it to an optimal state, and to perform a cost-benefit analysis in favor of any such efforts.

It is believed that this passage, in context, supports the claimed invention of inputting measurements of thermodynamically relevant parameters, and analyzing these with respect to the

system configuration and the laws of thermodynamics, i.e., a thermodynamic analysis, to yield a thermodynamic model. Further, the thermodynamic model may be analyzed with respect to operating parameters to determine a consistency, i.e., a consistency analysis. It is therefore respectfully submitted that applicant has provided an adequate written description of the invention as claimed, and in particular, the consistency analysis.

A thermodynamic analysis, also referred to a simply an analysis within the context of the normal operation of the refrigeration system based on its measured (thermodynamic) parameters is clearly disclosed in the specification, immediately following the foregoing cited section (which refers explicitly to thermodynamic considerations) see Page 16, lines 6-20:

> Typically, before extensive and expensive system maintenance is performed, it is preferable to instrument the system for real time performance monitoring, rather than simple **state analysis**. Such real time performance modeling is typically expensive, and not a part of normal system operation; whereas adequate information for a **state analysis** may be generally available from system controls. By employing a real time monitoring system, **analysis of operational characteristics** in a fluctuating environment may be assessed.
>
> This scheme may also be used in other types of systems, and is not limited to refrigeration systems. **Thus, a set of sensor measurements are obtained and analyzed with respect to system model**. The analysis may then be used to tune system operational parameters, instigate a maintenance procedure, or as part of a cost-benefit analysis. Systems to which this method may be applied include, among others, internal combustion engines, turbomachinery, hydraulic and pneumatic systems.
>
> **Preferably, the efficiency is recorded in conjunction with the process variables. Thus, for each system, the actual sensitivity of efficiency, detected directly or by surrogate measures, to a process variable, may be measured**.

See also, page 18, lines 6-13:

> Of course, it may not be possible to measure orthogonal (non-interactive) parameters. **Therefore, another aspect of the invention provides a capability for receiving a variety of data relating to system operation and performance, and analyzing system performance based on this data**. Likewise, during a continuous system performance monitoring, it may be possible to employ existing (normally occurring) system perturbations to determine system characteristics. Alternately, the system may be controlled to include a sufficient set of perturbations to determine the pertinent system performance parameters, in a manner which does not cause inefficient or undesirable system performance.

Page 36, line 27-page 37, line 21 states:

> EXAMPLE 2

> Fig. 7A shows a block diagram of a first embodiment of a control system according to the present invention. In this system, refrigerant charge is controlled using an adaptive control 200, with the control receiving refrigerant charge level 216 (from a level transmitter, e.g., Henry Valve Co., Melrose Park IL LCA series Liquid Level Column with E-9400 series Liquid Level Switches, digital output, or K-Tek Magnetostrictive Level Transmitters AT200 or AT600, analog output), optionally system power consumption (kWatt-hours), **as well as thermodynamic parameters, including condenser and evaporator water temperature in and out, condenser and evaporator water flow rates and pressure, in and out, compressor RPM, suction and discharge pressure and temperature, and ambient pressure and temperature**, all through a data acquisition system for sensor inputs 201. These variables are fed into the adaptive control 200 employing a nonlinear model of the system, based on neural network 203 technology. The variables are preprocessed to produce a set of derived variables from the input set, as well as to represent temporal parameters based on prior data sets. The neural network 203 evaluates the input data set periodically, for example every 30 seconds, and produces an output control signal 209 or set of signals. **After the proposed control is implemented, the actual response is compared with a predicted response based on the internal model defined by the neural network 203 by an adaptive control update subsystem 204, and the neural network is updated 205 to reflect or take into account the "error"**. A further output 206 of the system, from a diagnostic portion 205, which may be integrated with the neural network or separate, indicates a likely error in either the sensors and network itself, or the plant being controlled.
>
> The controlled variable is, for example, the refrigerant charge in the system. In order to remove refrigerant, liquid refrigerant from the evaporator 211 is transferred to a storage vessel 212 through a valve 210. In order to add refrigerant, gaseous refrigerant may be returned to the compressor 214 suction, controlled by valve 215, or liquid refrigerant pumped to the evaporator 211. Refrigerant in the storage vessel 212 may be subjected to analysis and purification.

It is therefore believed that the application as filed, provides an adequate written description and supports the full and enabling disclosure of a thermodynamic analysis and a consistency analysis of the type set forth in the claims, and thereby complies with the requirements of 35 U.S.C. § 112, first paragraph.

Claim 21 defines a model of a refrigeration system, determines physical parameters for performing a thermodynamic analysis of the refrigeration system, performs the thermodynamic analysis, and determines a consistency of the thermodynamic analysis with the defined model. The meaning of consistency in this context is unambiguous.

Claim 43 performs a thermodynamic analysis of a refrigeration system to derive a thermodynamic model, and then "perform[s] a consistency analysis of the thermodynamic model of the refrigeration system with respect to measured thermodynamic data of the refrigeration

system during operation at an operating state dependent on a set of operating physical parameters". There is simply no ambiguity as to what this consistency analysis refers to.

Claim 46 similarly provides a method which performs a thermodynamic analysis of refrigeration system operation, determines a model of the refrigeration system having an optimum state based on prior measurements of refrigeration system performance, and estimates a deviance from the optimum state of the refrigeration system, by performing a consistency analysis of the model of the refrigeration system derived from the thermodynamic analysis and measured operating parameters of the refrigeration system at a time when the refrigeration system is not operating at the optimum state. Thus, the meaning of the consistency analysis is clear.

Claim 39 is rejected in its reference to "thermodynamic modeling", which is allegedly not taught in the specification. Indeed, applicants reference Thome, J.R., "Comprehensive Thermodynamic Approach to Modelling Refrigerant-Lubricating Oil Mixtures", Intl. J. HVAC&R Research (ASHRAE) 1995, 110-126; Poz, M. Y., which is believed to provide background for interpretation of this phrase. The examiner is being unduly harsh in treating the various analyses of performance and operation of the refrigeration system discussed in the specification using its state variables, etc., as being anything other than a thermodynamic analysis, given the broad and specific teachings of the specification as a whole. Likewise, the various models and modeling of operation and performance of performance and operation of the refrigeration system discussed in the specification using its state variables, etc., are clearly thermodynamic models.

The examiner states quite unequivocally that the phrases "thermodynamic analysis" and "consistency analysis" were understood by the examiner (page 3, paragraph 7(c) of office action), and therefore the issue is really whether applicants essentially describe the "thermodynamic analysis" and "consistency analysis" in the specification. As documented above, it is clear that this is the case. Note that the original claims form part of the disclosure, and these phrases appear in the original claims. There can be no doubt that applicant possessed the invention at the time of filing, provided a written description thereof, and enabled the person of ordinary skill in the art to practice the invention. Therefore, all of the requirements of 35 U.S.C. § 112, first paragraph, are met. Reconsideration of the written description rejection is respectfully requested.

ENABLEMENT

Claims 18-59 are also rejected under 35 U.S.C. § 112, first paragraph, as allegedly not being supported by an enabling specification, and in particular, for failing to enable the phrases "thermodynamic analysis", "consistency analysis", and "thermodynamic modeling".

In general, the enabling support is similar with the support cited above with respect to the written description rejection. However, with respect to enablement, the examiner is required to propose a factual finding as to the level of skill in the art, and that a person with that defined level of skill would not have been enabled to practice the invention. In this case, the only relevant evidence presented by the examiner is a specific finding that Herbert (U.S. 7,139,564) and Keeler et al. (U.S. 6,243,696), references available to a person of ordinary skill, would render the invention obvious. Without acceding to the propriety of the art rejections, it is noted that a single reference obviousness rejection of a set of claims is inconsistent with a finding that those same claims are obvious, since these allegations are legally and factually inconsistent, in view of the fact that the prior art must itself be enabling for the claimed invention in order to render it obvious; non-enabling references do not negate patentability.

The Examiner rejects this analysis, however, reconsideration is respectfully requested. In particular, if Herbert is within the grasp of a person of ordinary skill for purposes of considerations of obviousness, then it must be taken as also within that person's skill for understanding of its content. Otherwise, the U.S.P.T.O. would fall under its own weight by requiring laborious recitation of textbook background information which is by law considered within the knowledge of the relevant persons.

The MPEP addresses this issue as follows:

> Undue experimentation - MPEP 2164.01:
>
> The test of enablement is whether one skilled in the art could make and use the claimed invention from the disclosure coupled with information known in the art without undue experimentation. United Stated v. Telectronics, Inc., 857 F.2d 778, 8 USPQ2d 1217 (Fed. Cir. 1988); In re Stephens, 188 USPQ 659 (CCPA 1976). The test of enablement is not whether any experimentation is necessary, but whether, if experimentation is necessary, it is undue. In re Angstadt, 190 USPQ 214 (CCPA 1976). An extended period of experimentation may not be undue if the skilled artisan is given sufficient direction or guidance. In re Colianni, 195 USPQ 150 (CCPA 1977) (Miller, J., concurring). The experimentation required, in addition to not being undue, must not require ingenuity beyond that expected of one of ordinary skill in the art. In re Angstadt, supra. For example, in one instance a "few hours" of experimentation to determine process parameters was not considered to be undue in view of the nature of the invention (preparation of oxygenated hydrocarbons). In re Borkowski, 164 USPQ 642 (CCPA 1970). In Tabuchi v. Nubel, 194 USPQ 521 (CCPA 1977) a screening procedure which took 15

calendar days was not considered undue experimentation because the test was both simple and straightforward and because of its demonstrated success in producing the desired result.

Specific factors which are to be considered in determining whether or not experimentation required is undue are (1) the quantity of experimentation necessary (time and expense); (2) the amount of direction or guidance presented; (3) presence of absence of a working example; (4) nature of the invention; (5) the state of the prior art; (6) the relative skills of those in the art; (7) the predictability or unpredictability of the art; and (8) the breadth of the claims. In re Wands, 858 F.2d 731, 8 USPQ 2d 1400 (Fed. Cir. 1988). Non-critical features of the invention may be supported by a more general disclosure than those at the heart of the invention. In re Stephens, 180 USPQ 659 (CCPA 1976).

One skilled in the art - MPEP 2164.05(b):

The specification only needs to describe the invention in sufficient detail to enable a person skilled in the most relevant art to make and use the invention. When an invention, in its different aspects, involves distinct arts, the specification is adequate if it enables the adepts of each art, those who have the best chance of being enabled, to carry out the aspect related to their specialty. In re Naquin, 158 USPQ 317 (CCPA 1968); Ex parte Zechnall, 194 USPQ 461 (Bd. of App. 1973); Ex Parte Billottet, 192 USPQ 413 (Bd. of App. 1976). A factual basis must be set forth to demonstrate that it would be beyond the level of ordinary skill in a particular art to make and use the invention. Mere conclusionary statements as to the level of ordinary skill in the art are not a sufficient basis for a ¤112 first paragraph rejection. In re Brebner, 173 USPQ 169 (CCPA 1972).

BURDEN OF PROOF - MPEP 2164.04

The Patent and Trademark Office has the initial burden of giving reasons, supported by the record as a whole, why the specification is not enabling. For example, showing that the disclosure entails undue experimentation is part of the initial burden. Also, concerning undue experimentation, the courts have held that merely demonstrating that some experimentation is necessary does not shift the burden to applicants to prove that such experimentation is not undue. In re Angstadt, supra. All assertions made that the enabling disclosure is not commensurate in scope with the protection sought by the claims must be supported by (I) evidence or (2) reasoning substantiating doubts so expressed. In re Dinh-Nguyen, 181 USPQ 46 (CCPA 1974). Reasons and evidence sufficient to create reasonable doubt as to the accuracy of a particular broad statement put forward as enabling support for a claim can take any of the following forms: (I) statements on their face contrary to generally accepted scientific principles; (2) teachings in pertinent references; and (3) unpredictability of chemical reactions. In re Marzocchi, supra. Assuming that sufficient reason for such doubt does exist, a rejection for failure to teach how to make and/or use the invention will be proper on that basis. Such rejection can be overcome by suitable evidence that the teaching contained in the specification is truly enabling. In re Marzocchi, supra. In any event, it is incumbent upon the Patent and Trademark Office to explain why it doubts the truth or accuracy of any statement in a supporting disclosure and to back up assertions of its own with acceptable evidence or reasoning which is inconsistent with the contested statement. In re Marzocchi, supra. Once the examiner has advanced a reasonable basis for questioning the adequacy of the disclosure, it is incumbent upon applicant to rebut that challenge. That is, the applicant has the burden of supplying adequate information from which the examiner could base a finding of whether the examiner's challenge is correct, e.g. factual support as to what would be required or what was actually done in carrying out the invention. In re Doyle, 482 F.2d 1385, 179 USPQ 227 (CCPA 1973).

The examiner has the initial burden to establish a reasonable basis to question the enablement provided for the claimed invention. If an examiner can provide reasons sufficient to create a reasonable doubt as to the accuracy of a particular broad statement put forward by applicant as enabling support for a claim, a rejection under 35 U.S.C. 112, first paragraph can be made. A specification disclosure which contains a teaching of the manner and process of making and using the invention in terms which correspond in scope to those used in describing and defining the subject matter sought to be patented must be taken as in compliance with the enabling requirement of the first paragraph of ¤112 unless there is reason to doubt the objective truth of the statements contained therein which must be relied on for enabling support. Assuming that sufficient reason for such doubt

exists, a rejection for failure to teach how to make and/or use will be proper on that basis. In re Marzocchi, 169 USPQ 367 (CCPA 1971).

By positing the obviousness rejection, the examiner thus admits that a person of ordinary skill ***would have been enabled to practice the claimed invention*** in view of the knowledge of the prior art imputed to him, since the combination of references must itself be enabling to establish a prima facie case of obviousness. To the extent that the examiner concludes that applicant's own "admitted prior art" was unavailable to persons or ordinary skill in the art at the time the invention was made, and therefore do not reflect the subjective state and knowledge of such a person, applicants note that the art rejection, though based on applicants' admission, requires a motivation in the art to combine, and therefore if such information was not actually available to such persons, the obviousness rejection is thereby defeated. Since the obviousness rejections are presumably well-reasoned, and the enablement rejection is merely conclusory, the latter should be withdrawn as being unsupported and contradictory.

Note that the Examiner has failed to specifically define the person of ordinary skill in the art, which is the examiner's burden and a requirement for a prima facie case of obviousness under 35 U.S.C. § 103 (see KSR) or lack of enablement under 35 U.S.C. § 112 (see, e.g., In re Marzocchi, 169 USPQ 367 (CCPA 1971)).

On the other hand, applicants have directly addressed the enablement rejection by particularly pointing to sections of the specification and otherwise the state of knowledge of a person of ordinary skill, and thus the enablement rejection fails in any case. The examiner has completely failed to state exactly what would not have been within the skill of a person or ordinary skill in the art, what outcome might be unpredictable, etc., or otherwise present an analysis under In re Wands. The rejection is merely a bald assertion without any factual support. Reconsideration of the enablement rejection is respectfully requested.

OBVIOUSNESS

Claims 39-45 are rejected under 35 U.S.C. § 103(a) as being obvious in view of Hebert (US 7,139,564) in view of applicant's admitted prior art.

Independent claims 39 provides:

39. A method, comprising the steps of:
thermodynamically modeling a refrigeration system to generate a thermodynamic model, **and a determining a sensitivity of an optimum state of the refrigeration**

system to perturbations, the refrigeration system comprising a refrigerant having a refrigerant purity and a compressor operating at a compressor power, **with respect to at least the refrigerant purity and a superheat level**;

measuring an actual performance of the refrigeration system;

predicting a thermodynamic effect of an alteration of the refrigerant purity and the compressor power with respect to the measured performance and the thermodynamic model based on at least a consistency of the actual performance of the refrigeration system with the performance of the refrigeration system at the optimum state and the determined sensitivity;

altering the refrigerant purity and the compressor power to achieve a predicted optimum condition of the refrigeration system under operating conditions.

As noted, claim 39 addresses the issues of both **sensitivity of an optimum state of the refrigeration system to perturbations** and **refrigerant purity**, neither of which are considerations of Hebert. The examiner calls on applicants' admitted prior art to remedy this deficiency. However, while it was indeed known that degradation in refrigerant purity alters refrigeration system performance, the determination of a sensitivity of an optimum state of a refrigeration system to perturbations with respect to at least the refrigerant purity and superheat level, and predicting a thermodynamic effect of an alteration of the refrigerant purity and the compressor power with respect to the measured performance and the thermodynamic model based on at least a consistency of the actual performance of the refrigeration system with the performance of the refrigeration system at the optimum state and the determined sensitivity, were not taught or suggested in the art, and indeed it is believed that this is a particular contribution by applicants. As discussed above, most inventions build on the prior art. In this case, there was indeed a long need to quantitatively understand the effect of refrigerant purity on actual performance, and this required the exercise of inventive skill to achieve practical application, as set forth in claim 39. Note that claim 39 does not simply provide that the refrigerant should be purified. Rather, the sensitivity of the refrigeration system power efficiency is considered, thereby allowing a cost-effective remediation balancing the cost of remediation to the cost of power to be saved.

This issue is also not addressed by the examiner in the Action, and therefore it is believed that the examiner has failed to present a prima facie case of obviousness. Reconsideration is respectfully requested.

Claim 43 provides:

43. A method, comprising the steps of:

<u>performing a thermodynamic analysis of a refrigeration system to derive a thermodynamic model of the refrigeration system to determine an optimal state of the refrigeration system</u>;

performing a consistency analysis of the thermodynamic model of the refrigeration system with respect to measured thermodynamic data of the refrigeration system during operation at an operating state dependent on a set of operating physical parameters; and

<u>presenting an estimate of a deviance of the operating state from an optimal state</u> of the refrigeration system sensitive to at least said thermodynamic analysis and said consistency analysis.

Hebert does not teach or suggest performing any analysis to derive a model of a refrigeration system "to **<u>determine</u>** an optimal state of the refrigeration system". Rather, Hebert appears to accept the nominal data as a benchmark, without any such determination of an "optimum state", or indeed any recognition that the nominal state may be anything but optimal, and therefore obviating any such determination. Likewise, Hebert does not appear to present "an estimate of a deviance of the operating state from an optimal state of the refrigeration system sensitive to at least said thermodynamic analysis and said consistency analysis". Therefore, even were the consistency analysis assumed *arguendo* obvious, per the assertion of the examiner, the claim further includes additional subject matter which is not addressed by the reference or applicants' admitted prior art. The consistency analysis is not a simple data error check—the data is correct, and the system is operating according to thermodynamic principles. Rather, the analysis seeks to determine consistency with parameters describing operation of the system with those that are optimal, with an interpretation of those differences being considered in a thermodynamic context.

It is noted that the optimum state of a system may differ from the as-manufactured or nominal "clean" state. For example, in a refrigeration system, the nominal or as-installed state isolates the compressor oil from the evaporator, and a generally analysis assumes that efficiency declines as the oil level in the evaporator increases. In fact, a small amount of oil in the evaporator (not part of the nominal specifications of the refrigeration system) leads to an enhancement in heat transfer, and thus efficiency **<u>rises</u>** slightly after use. See Fig. 5 and page 36, lines 13-26. Likewise, in some cases, a frothing of the refrigerant in the evaporator is beneficial, since it helps to coat the upper tubes in the evaporator. Therefore, the nominal or benchmark

state is not necessarily the optimum state. Therefore applicants respectfully request reconsideration of specifically paragraph 9(c) of the Action (p. 6).

Therefore, while modeling of systems was in general known (see, e.g., Keeler et al., Wikipedia, etc.), the use of such models in the manner claimed is not obvious to a person of ordinary skill in view of the prior art. In any case, the examiner has failed to present a prima facie case of obviousness as required by KSR, since material elements of the claim are not particularly addressed and enunciated. Reconsideration of the rejection is respectfully requested.

If required to advance prosecution, and achieve allowability of the application, applicants will agree to amend claims 43-45 by Examiner's amendment to conform to the distinctions of claims 18, 21, and 46 (without admitting any deficiency in their present arguments distinguishing claims 39-45 from the art), i.e., an express limitation that the thermodynamic model or analysis is of the same apparatus being subject to measurement of data. It is believed, however, that such amendments are not necessary.

Claims 18, 21 and 46, and their respective dependent claims, are rejected as being obvious under 35 U.S.C. § 103 over Hebert, applicants' admitted prior art, and newly cited Keeler et al., US 6,243,696.

While applicants to not accede to the applicability of Keeler et al. in this context, applicants do admit that the formulation of a thermodynamic model is a corollary of amassing a sufficient amount of thermodynamic data to perform a thermodynamic analysis, and the art clearly teaches performing thermodynamic analyses of refrigeration systems and the like. However, the present claims are not limited to, or distinguished from the art by, the mere generation of a thermodynamic model, but rather by its particular use in accordance with the present claims.

Hebert implements a system and method where operational parameters of a HVAC/refrigeration system are compared to **nominal** values of the same type of system, to determine a deviation. Applicants do not contest that Hebert employ thermodynamic parameters in an analysis, see HVAC Implementation II(C)(ii), Col. 6, line 62-Col. 7, line 28. Hebert discusses performing thermodynamic calculations of a particular system at a particular state, and determining whether these are consistent with the manufacturers' specifications for that type of system (Col. 12, lines 8-11; Col. 12, lines 30-34; Col. 13, lines 11-14). To this extent, there is no

need to consider Keeler et al., since Keeler et al. provides no additional substantive relevant teachings beyond applicants' admitted prior art.

Hebert, however, does **not** seek to determine the actual optimum state of a particular refrigeration system with respect to **its own performance** (or indeed, the optimum state in any context). This determination, for example, requires an exploration of the operational space to determine the impact of changes in a plurality of different factors on performance. This, however, is taught in the present specification, see Examples 3 and 4, pp. 37-40. In fact, the optimum state of a refrigeration system is dependent on a number of factors and presumptions, as well as installation-specific characteristics, so that a comparison with a nominal is of limited value and may lead to a correction of the refrigeration system to a **less** efficient operating state in some cases. Thus, the reference "model" of the refrigeration system, if any, created by Hebert is a theoretical one based on nominal performance data and not one which is based on actual measurements, and does not account for installation-specific issues, aging, and manufacturing variations. Thus, neither Hebert nor Keeler et al. can determine an installation-specific optimum.

If one were to combine Keeler et al. with Hebert and Applicant's admitted prior art, the result would still not be applicants claimed invention. Keeler et al. and indeed the application of known thermodynamic modeling techniques, only advises what the actual state of a system is. If the model is created at the time of installation in a "clean" state, one might derive a nominal model and understand the nominal machine specific performance. However, without an exploration of the actual operating parameters, these techniques would not result in a realization of the **optimum** state, or an understanding of the **optimum performance** of the system. The presence of this issue within the claims (including claims 39 and 43) is clear, as follows:

> 18. An apparatus, comprising:
>
> a memory, storing parameters of a model of a refrigeration system derived from measurements of actual operational parameters of the refrigeration system;
>
> at least one input for receiving physical parameters sufficient for performing a thermodynamic analysis of the refrigeration system;
>
> a processor for performing a thermodynamic analysis of the refrigeration system in an operating state and determining consistency of the thermodynamic analysis with the stored parameters in the memory; and
>
> **an output for presenting an estimate of deviance from an optimal state of the refrigeration system based on said thermodynamic analysis and said determined consistency**.

21. A method for determining a deviance from optimum of a refrigeration system, comprising:

defining a model of a refrigeration system in an optimal state based on measurements of actual operating parameters of the refrigeration system;

obtaining physical parameters for performing a thermodynamic analysis of the refrigeration system at a time when the refrigeration system is not performing optimally;

performing a thermodynamic analysis of the refrigeration system based on the obtained physical parameters;

determining a consistency of the thermodynamic analysis with the defined model of the refrigeration system; and

outputting an estimate of deviance of the state of the refrigeration system at the time when the refrigeration system is not performing optimally from the determined optimal state of the refrigeration system based on said thermodynamic analysis and said determined consistency.

39. A method, comprising the steps of:

thermodynamically modeling a refrigeration system to generate a thermodynamic model, and a determining a sensitivity of an optimum state of the refrigeration system to perturbations, the refrigeration system comprising a refrigerant having a refrigerant purity and a compressor operating at a compressor power, with respect to at least the refrigerant purity and a superheat level;

measuring an actual performance of the refrigeration system;

predicting a thermodynamic effect of an alteration of the refrigerant purity and the compressor power with respect to the measured performance and the thermodynamic model based on at least a consistency of the actual performance of the refrigeration system with the performance of the refrigeration system at the optimum state and the determined sensitivity;

altering the refrigerant purity and the compressor power to achieve a predicted optimum condition of the refrigeration system under operating conditions.

43. A method, comprising the steps of:

performing a thermodynamic analysis of a refrigeration system to derive a thermodynamic model of the refrigeration system to determine an optimal state of the refrigeration system;

performing a consistency analysis of the thermodynamic model of the refrigeration system with respect to measured thermodynamic data of the refrigeration system during operation at an operating state dependent on a set of operating physical parameters; and

presenting an estimate of a deviance of the operating state from an optimal state of the refrigeration system sensitive to at least said thermodynamic analysis and said consistency analysis.

46. A method for analyzing a refrigeration system, comprising measuring physical parameters sufficient for performing a thermodynamic analysis of refrigeration system operation and performing a thermodynamic analysis of the refrigeration system,

> **determining a model of the refrigeration system having an optimum state based on prior measurements of refrigeration system performance, and estimating a deviance from the optimum state of the refrigeration system**, by performing a consistency analysis of the model of the refrigeration system derived from the thermodynamic analysis and measured operating parameters of the refrigeration system **at a time when the refrigeration system is not operating at the optimum state**, and outputting the estimate of the deviance from the optimal state of the refrigeration system based on said consistency analysis.

Thus, it is respectfully submitted that the claims include clear and distinct language which distinguishes the art, and provides a materially different system from Hebert which achieves a different result. The optimization of refrigeration systems is complex, and the art has long tried to address this problem. The art generally teaches that the "clean" or nominal state of the refrigeration system is a desired state, and not that the optimum state is materially different from the nominal state. However, the present application teaches that the optimum state may be different, and indeed may change with environment of operation. Therefore, the art is believed distinguished, and the rejection traversed.

Reconsideration of the rejections of the claims as being obvious in view of the art is respectfully solicited.

If the examiner believes it would be helpful to resolve the outstanding issues, applicants' undersigned attorney invites a telephone conference wherein material resolution or simplification of the issues might be possible.

Respectfully submitted,

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